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POTENTIAL OF CEREAL BY-PRODUCTS FROM ETHANOL PRODUCTION AS FEED INGREDIENTS FOR SWINE PRODUCTION

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Final Report

Potential of Cereal By-Products from Ethanol Production as Feed Ingredient for Swine Production

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Summary

With the tremendous growth of the ethanol industry, more and more by-products - namely, distiller's grains and thin stillage (DDGS) are available for livestock rations. The nutritional value of dried wheat distiller's grain for grower-finisher pigs is presently unknown. A digestibility experiment was completed with cannulated grower-finisher pigs fed one wheat control diet and 3 dried distiller's grain diets (corn, corn and wheat, and wheat distiller's grain). Ingredient, feed, faeces, and digesta samples were collected and were analyzed to determine DE, digestible amino acid, and digestible phosphorus content for the three DDGS samples. The pigs consumed the diets containing wheat distiller's grain, suggesting that this project will be a worthwhile undertaking for the ethanol and the swine industry. All objectives for year 1 of the project were achieved, and an updated proposal for further work will be presented at the next funding round of ADF.

Technical Report

Background

With the tremendous growth of the ethanol industry, more and more by-products - namely, distiller's grains and thin stillage are available for livestock rations. In general, these by-products have higher concentrations of fibre, crude protein, fat, vitamins and minerals than their parent grains. This concentration of nutrients results from the removal of much of the starch fraction as ethanol and carbon dioxide, during the fermentation process. Wheat and corn distiller's grains are feed ingredients that might have potential for the pork industry. For any feed ingredient, it is critical to understand contents of nutrients, in particular the digestible nutrient content. Only then is precise diet formulation possible. As part of a larger project, the first step was to measure the digestible energy and amino acid contents of wheat and corn distiller's grain in grower pigs.

Project Objectives

As feed ingredients, wheat and corn distiller's grains might contain a valuable digestible energy and amino acid content for swine production. Corn distiller's grain is expected to have the highest digestible energy content, because wheat distiller's grain contains more fibre than corn distiller's grain, but wheat distiller's grain should be valuable as well.

1. To determine the digestible energy content of wheat and corn distiller's grains.
2. To determine apparent ileal digestible amino acid content of wheat and corn distiller's grains.
3. To determine the total and digestible phosphorus content of wheat and corn distiller's grains.

Materials and Methods

Experimental design

Four diets were tested in two experimental periods using cannulated grower pigs (Table 1): one wheat control diet and 3 dried distiller's grain diets (corn, corn and wheat, and wheat distiller's grain). A minimum of 12 cannulated pigs (PIC, average BW 50-60 kg) were fed two experimental diet each, for a total of 24 observations or six observations per diet. The experimental period was 11 days: a 6-day acclimation to an experimental diet followed by a 3-day collection of feces and urine and a 2-day collection of ileal digesta.

Facilities and equipment

Metabolism room 124 was used for the experiment for 30 day including metabolism pens. The room housed 12 pigs in individual pens. The dimensions of the individual pens are 1.5 (length) x 1.5 (width) x 0.9 m (height), and allow freedom of movement of pigs during the entire experiment. The flooring of the pen is plastic-coated expanded metal (Tenderfoot) and the siding is sturdy PVC-planking. A single-space feeder and a bowl-drinker are located at the front of the pen.

Ingredient and nutrient composition of diets

Diet A contained wheat as the sole energy and amino acid source. Diets B, C, and D contained wheat and distiller's grain as energy and amino acid sources (Table 3). Diet A contained 15 to 16% protein and the distiller's grain diets were higher in protein content. An indigestible marker, chromic oxide, was added to each diet. Diets were fortified with premixes to meet or exceed vitamin and mineral requirements.

Diet processing

For the wheat and wheat/corn distiller's grain, 700 kg was received from Mohawk Canada, Minnedosa, MB. For the corn distiller's grain, 1,000 kg was received from Federated Co-op, Saskatoon, SK. For each ingredient, a composite sample (approximately 3 kg) was retained in PSCI's office building.

Hand-added ingredients included in the experimental diets were weighed out at the PSCE Feed Mill and transported to the University's Poultry Science facility. The distiller's grains and ground wheat (sample Arm River, 8/64"-screen) were weighed accurately according to the mix-sheets and added to a horizontal 250-kg mixer. Diets were each mixed in one batch of 200 kg, and a proper sub-sample was collected.

Management

Barrows PIC (C21 x Line 65) were be fitted with a T-cannula at the distal ileum. Cannulation surgeries and recovery were conducted according to an existing SOP. Following recovery, the pigs have been used for two experimental periods for another purpose.

The room was maintained within thermo-neutral zone of the pigs, with a 14 hr light (0700 to 2100)/10 hr dark cycle.

The diet was provided as a wet mash. Feed was added to the feeder followed immediately with 1:1 water, during the entire experiment. Pigs had free access to water.

Feed Management. The pigs were first fed regular production diet for 10 days during a transfer period upon completion of a previous experiment. Then, pigs were fed experimental diets for 11 days, the first six days as an acclimation and the last five days to collect feces and urine or digesta. Pigs were fed at 2.6 x the maintenance requirement using an estimated diet DE content of 3,300 kcal/kg. Feeders were checked daily to ensure free flow of feed.

Animal care

An animal care protocol (#19980106; Determination of ileal and fecal digestibility of nutrients in experimental diets fed to grower-finisher pigs) written specifically for experiments with cannulated pigs was recently reviewed and approved (Sep 26, 2002) by the University Committee of Animal Care and Supply of the University of Saskatchewan. Pigs were cared for following PSCI's Standard Operating Procedures.

Data and sample collection methods

A total of 4 diet, 24 fecal, and 24 digesta samples were collected.

Feed. During the collection periods, feed was collected. Collected feed samples were stored in a freezer maintained at –20 °C.

Feces. Feces were collected for 3 days for a minimum of two times a day (0800 and 1600) using feces collection systems. Collected feces were pooled over the collection period into one bag per pig, which were stored in a freezer maintained at –20 °C.

Digesta. Digesta was collected for 2 days using bags containing diluted formic acid attached to the opened cannula barrel for 10 hr. Collected digesta was pooled over the collection period into one container per pig, which was stored in a freezer maintained at –20 °C.

Pigs. Pigs were weighed and the start and end of each experimental period.

Sample processing and laboratory analyses

Norwest Labs tested the distiller's grain for standard nutrient composition (Table 2) and moisture and crude protein were analyzed at DAPS.

After the collections were completed, feces samples were thawed, homogenized, and transferred to designated bags. Digesta samples were thawed, homogenized, and transferred to designated trays. Then, samples were freeze-dried. Once freeze-dried, samples were equilibrated to room temperature and moisture for 2 to 4 h. Thereafter, diet and freeze-dried fecal, digesta, and urine samples were ground, mixed and stored in properly identified containers.

Lab analyses. Freeze-dried samples of diets, feces, and digesta were analyzed at the Department of Animal & Poultry Science, University of Saskatchewan for moisture and gross energy content. Feed and digesta samples were analyzed to the University of Missouri for analyses of moisture amino acids content. Feed and digesta were analyzed at the Department of Animal & Poultry Science for protein and chromic oxide and moisture content.

Calculations and statistical analyses

Using chromic oxide concentrations in diet, feces, and digesta, digestibility of energy, amino acids, and phosphorus were calculated to determine ileal DE and amino acid content and total-tract DE, amino acid, and phosphorus content for each pig observation. Subsequently, digestible nutrient profile was calculated for each of the three DDGS samples using the difference method, i.e., the digestible nutrient content for wheat was deducted from the digestible nutrient content for the DDGS-diets. Data were not analysed statistically, because the main objective was to determine the digestible nutrient profiles for each of the three DDGS samples.

Results and Discussion

Total nutrient content. For wheat distiller's grain, the protein content is higher and the fat content is lower than for corn distiller's grain, while the fibre content is similar (Table 1). The results of chemical analyses suggest that the measured DE content for wheat distiller's grain will be lower than for corn distiller's grain and the measured digestible amino acid content will be higher for the wheat distiller's grain.

Performance. Pigs were willing to eat diets containing 40% dried wheat distiller's grain during the digestibility experiment, suggesting than consumption of the ingredient at expected levels in swine diets (10 to 25%) may not reduce performance of grower-finisher pigs. The validity of this hypothesis is currently being tested in a performance study.

DE content. The DE content of corn, wheat + corn, and wheat DDGS was 3435, 3325, and 3335 kcal /kg as fed. Indeed the DE content for corn DDGS was highest.

Digestible amino acid content. Overall, digestible amino acid content was higher for the wheat + corn and wheat DDGS than the corn DDGS. Still, the digestible amino acid content for lysine was higher for corn DDGS, indicating that some of the lysine may have been damaged during processing the wheat + corn and wheat DDGS.

Total and digestible phosphorus. The total phosphorus content of DDGS product is high, and the digestibility of the phosphorus is much higher than generally observed for cereal grains and legume seeds. Perhaps the phytate complex is broken down during the fermentation and (or) subsequent drying process, resulting in reduced negative impact of phytate on nutrient, and in particular phosphorus digestibility.

Conclusions

Pigs seem to be willing to eat diets containing dried distiller's grain plus solubles (DDGS). As expected, corn DDGS had the highest DE and lowest digestible amino acid content. Wheat and wheat + corn DDGS seems to have a digestible nutrient profile that seems to make them worthwhile feed ingredients to be included in swine diets; however, their impact on swine growth performance needs to be determined. An experiment to determine the impact of 25% DDGS inclusion into diets formulated to an equal digestible nutrient content compared to a control diet is currently ongoing. A new application will be submitted to ADF in May to further improve the nutritional value of DDGS for swine, specifically looking at reducing the negative impact of the high fibre content and reducing the negative impact of drying the DDGS.

Personnel

Laura Kiehlbauch was working on the project as an animal technician. Gemunu Widyaratne has been working on the project since September 1 as a graduate student.

Equipment

Equipment was not purchased.

Project Developed Materials

Deliverables have not been developed to date. Data from this study will be presented in the 2004 Annual Research Report of Prairie Swine Centre and in a Prairie Swine Centre newsletter. Some data from the project will be presented at the 2004 Western Nutrition Conference to be held in Saskatoon.

Project Photos

Photos were not taken.

Acknowledgements

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Table 1. Nutrient composition of distiller's grains used in the study

Nutrient	Unit	Distiller's grain		
		Corn	Wheat/Corn	Wheat
Analyzed, as fed[a]				
Moisture	%	12.9	7.9	8.5
Crude protein	%	27.0	38.9	41.7
Analyzed, as fed[b]				
Moisture	%	10.3	5.1	6.0
Ash	%	4.32	4.78	4.94
Crude protein	%	27.2	40.3	41.8
Acid-detergent Fibre	%	15.4	14.3	13.5
Neutral-detergent Fibre	%	37.5	39.0	39.5
Crude Fibre	%	6.3	7.4	7.1
Crude Fat	%	11.5	4.5	2.7
Predicted				
Nitrogen-free Extract	%	45.0	40.0	39.8
Digestible Energy	Mcal/kg	3.35	3.32	3.23
Metabolisable Energy	Mcal/kg	3.13	3.00	2.89

[a] Analyzed at DAPS

[b] Analyzed by Norwest Labs (Lethbridge, AB)

Table 2. Ingredient composition of diets

	Diet A Control Wheat	Diet B Corn Distiller's grain	Diet C Wheat/Corn Distiller's grain	Diet D Wheat Distiller's Grain
Ingredients (%)				
Wheat	96.3	56.3	56.3	56.3
Corn distiller's grain	-	40.0	-	-
Wheat/Corn distiller's grain	-	-	40.0	-
Wheat distiller's grain	-	-	-	40.0
Limestone	1.1	1.1	1.1	1.1
Di-calcium phosphate	0.8	0.8	0.8	0.8
Mineral mix	0.5	0.5	0.5	0.5
Vitamin mix	0.5	0.5	0.5	0.5
Chromic oxide	0.4	0.4	0.4	0.4
Salt	0.4	0.4	0.4	0.4
Total	100.0	100.0	100.0	100.0
Estimated nutrient content (as is)				
DE (kcal/kg)	3300	-	-	-
Crude protein (%)	15.0	20	25	26

Table 3. Ileal and total tract digestible energy (DE) content in the test wheat and the three dried distiller's grain plus solubles (DDGS) ingredient samples (DM and as-fed basis)

		DDGS		
DE content, % DM	Wheat	Corn	Wheat + Corn	Wheat
% DM				
Ileal DE	3206	3375	3223	3081
Total-tract DE	3786	3895	3613	3629
% As-fed				
Ileal DE	2829	2977	2965	2831
Total-tract DE	3341	3435	3325	3335

Table 4. Apparent ileal digestible amino acid content in the test wheat and the three dried distiller's grain plus solubles (DDGS) ingredient samples (DM basis)

		DDGS		
Amino acid, % DM	Wheat	Corn	Wheat + Corn	Wheat
Lysine	0.37	0.43	0.39	0.33
Threonine	0.40	0.71	0.99	0.93
Methionine	0.25	0.54	0.62	0.56
Cysteine	0.38	0.43	0.70	0.68
Tryptophan	0.18	0.18	0.26	0.31
Arginine	0.80	1.04	1.38	1.44
Histidine	0.40	0.60	0.73	0.73
Isoleucine	0.57	0.77	1.12	1.13
Leucine	1.09	2.98	2.71	2.41
Phenylalanine	0.83	1.17	1.70	1.77
Valine	0.71	1.19	1.56	1.52
Asparagine	0.69	1.32	1.45	1.27
Serine	0.67	0.97	1.50	1.48
Glutamate	5.76	3.41	9.34	10.38
Proline	1.79	1.62	3.04	3.63
Glycine	0.56	0.66	1.01	1.05
Alanine	0.46	1.63	1.24	1.00
Tyrosine	0.47	0.89	1.06	1.03
Total	17.25	20.27	30.57	33.51

Table 5. Apparent ileal digestible amino acid content in the test wheat and the three dried distiller's grain plus solubles (DDGS) ingredient samples (as-fed basis)

		DDGS		
Amino acid, % as-fed	Wheat	Corn	Wheat + Corn	Wheat
Lysine	0.32	0.38	0.36	0.3
Threonine	0.35	0.63	0.91	0.88
Methionine	0.22	0.48	0.57	0.52
Cysteine	0.34	0.38	0.64	0.62
Tryptophan	0.16	0.16	0.24	0.29
Arginine	0.71	0.92	1.27	1.32
Histidine	0.35	0.53	0.67	0.67
Isoleucine	0.5	0.68	1.03	1.04
Leucine	0.97	2.62	2.49	2.22
Phenylalanine	0.73	1.03	1.56	1.62
Valine	0.63	1.05	1.43	1.4
Asparagine	0.61	1.16	1.33	1.17
Serine	0.59	0.86	1.38	1.36
Glutamate	5.08	3	8.59	9.54
Proline	1.58	1.43	2.8	3.33
Glycine	0.49	0.58	0.93	0.96
Alanine	0.4	1.44	1.14	0.91
Tyrosine	0.42	0.79	0.97	0.94
Total	15.22	17.87	28.13	30.79

Table 6. Total and digestible phosphorus content in the test wheat and the three dried distiller's grain plus solubles (DDGS) ingredient samples (as-fed basis)

		DDGS		
Phosphorus, % as-fed	Wheat	Corn	Wheat + Corn	Wheat
Total	0.24	0.84	1.02	1.10
Digestible	0.03	0.38	0.49	0.49